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|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|--------|
| 1911 | 1912 | 1913 | 1914 | 1915 | 1916 | 1917 | 1918 | 1919 | 1920 | 1921 | 1922 | 1923 | 1924 | 1925 | 1926 | 1927 | 1928 | 1929 | 1930 | 1931 | 1932 | 1933 | 1934 | 1935 | 1936 | 1937 | 1938 | 1939 | 1940 | 1941 | 1942 | 1943 | 1944 | 1945 | 1946 | 1947 | 1948 | 1949 | 1950 | 1951 | 1952 | 1953 | 1954 | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 | 2040 | 2041 | 2042 | 2043 | 2044 | 2045 | 2046 | 2047 | 2048 | 2049 | 2050 | 2051 | 2052 | 2053 | 2054 | 2055 | 2056 | 2057 | 2058 | 2059 | 2060 | 2061 | 2062 | 2063 | 2064 | 2065 | 2066 | 2067 | 2068 | 2069 | 2070 | 2071 | 2072 | 2073 | 2074 | 2075 | 2076 | 2077 | 2078 | 2079 | 2080 | 2081 | 2082 | 2083 | 2084 | 2085 | 2086 | 2087 | 2088 | 2089 | 2090 | 2091 | 2092 | 2093 | 2094 | 2095 | 2096 | 2097 | 2098 | 2099 | 2100 | 2101 | 2102 | 2103 | 2104 | 2105 | 2106 | 2107 | 2108 | 2109 | 2110 | 2111 | 2112 | 2113 | 2114 | 2115 | 2116 | 2117 | 2118 | 2119 | 2120 | 2121 | 2122 | 2123 | 2124 | 2125 | 2126 | 2127 | 2128 | 2129 | 2130 | 2131 | 2132 | 2133 | 2134 | 2135 | 2136 | 2137 | 2138 | 2139 | 2140 | 2141 | 2142 | 2143 | 2144 | 2145 | 2146 | 2147 | 2148 | 2149 | 2150 | 2151 | 2152 | 2153 | 2154 | 2155 | 2156 | 2157 | 2158 | 2159 | 2160 | 2161 | 2162 | 2163 | 2164 | 2165 | 2166 | 2167 | 2168 | 2169 | 2170 | 2171 | 2172 | 2173 | 2174 | 2175 | 2176 | 2177 | 2178 | 2179 | 2180 | 2181 | 2182 | 2183 | 2184 | 2185 | 2186 | 2187 | 2188 | 2189 | 2190 | 2191 | 2192 | 2193 | 2194 | 2195 | 2196 | 2197 | 2198 | 2199 | 2200 | 2201 | 2202 | 2203 | 2204 | 2205 | 2206 | 2207 | 2208 | 2209 | 2210 | 2211 | 2212 | 2213 | 2214 | 2215 | 2216 | 2217 | 2218 | 2219 | 2220 | 2221 | 2222 | 2223 | 2224 | 2225 | 2226 | 2227 | 2228 | 2229 | 2230 | 2231 | 2232 | 2233 | 2234 | 2235 | 2236 | 2237 | 2238 | 2239 | 2240 | 2241 | 2242 | 2243 | 2244 | 2245 | 2246 | 2247 | 2248 | 2249 | 2250 | 2251 | 2252 | 2253 | 2254 | 2255 | 2256 | 2257 | 2258 | 2259 | 2260 | 2261 | 2262 | 2263 | 2264 | 2265 | 2266 | 2267 | 2268 | 2269 | 2270 | 2271 | 2272 | 2273 | 2274 | 2275 | 2276 | 2277 | 2278 | 2279 | 2280 | 2281 | 2282 | 2283 | 2284 | 2285 | 2286 | 2287 | 2288 | 2289 | 2290 | 2291 | 2292 | 2293 | 2294 | 2295 | 2296 | 2297 | 2298 | 2299 | 2300 | 2301 | 2302 | 2303 | 2304 | 2305 | 2306 | 2307 | 2308 | 2309 | 2310 | 2311 | 2312 | 2313 | 2314 | 2315 | 2316 | 2317 | 2318 | 2319</ |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|--------|

electrically conductive
and second supporting
element.

3 3. The device of Claim 1, wherein the second electrically conductive end termination is disposed on the first and second supporting substrates and the second end of the PTC element

4 4. The device of Claim 1, wherein the electrode disposed on the first substrate is in direct contact with the first end termination.

5 5. The device of Claim 1, wherein the electrode disposed on the second substrate is in direct contact with the second end termination.

6 6. The device of Claim 1, wherein the first and second supporting substrates are electrically insulative.

7 7. The device of Claim 1, wherein the first and second supporting substrates having electrodes disposed on first surfaces thereof are comprised of a copper clad PC board.

8 8. The device of Claim 1, wherein the first and second supporting substrates are formed from a material selected from the group including ceramic, glass, FR-4 epoxy and melamine.

9. The device of Claim 1, wherein the first electrically insulating substrate has a first end and a second end, and the electrode disposed on the first surface of the first

supporting substrate extends to one of the first or second end of the substrate but not the other of the first or second end of the substrate.

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Si₃N₄
C₂

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The device of Claim ~~9~~⁷, wherein the electrode disposed on the first surface of the first supporting substrate is in direct contact with one of the first or second electrically conductive end terminations but not the other of the first or second electrically conductive end terminations.

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Si₃N₄
O₂

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11.

The device of Claim 1, further comprising:
a third supporting substrate having an electrode disposed on a first surface thereof;
the second supporting substrate having a second electrode disposed on a second surface thereof; and
a second PTC element comprised of a polymer having conductive particles dispersed therein, the second PTC element positioned between the electrode disposed on the first surface of the third supporting substrate and the second electrode disposed on the second surface of the second supporting substrate.

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The device of Claim ~~11~~⁹, wherein the first PTC element and the second PTC element are electrically connected in parallel.

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11 13. The device of Claim 1 wherein when the device is electrically connected to a circuit having an electrical current flowing therethrough, the electrical current flows from the first electrically conductive end termination to the electrode disposed on the first surface of the first supporting substrate, through the PTC element to the electrode disposed on the first surface of the second supporting substrate, to the second electrically conductive end termination.

12 14. The device of Claim 1, wherein the first and second electrically conductive end terminations are comprised of a plurality of conductive layers.

13 15. The device of Claim 1, wherein the electrodes are comprised of a metal foil.

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16. A surface-mountable electrical circuit protection device comprising:
 a first substrate having an electrode disposed on a first surface thereof;
 a second substrate having an electrode disposed on a first surface thereof and a second electrode disposed on a second surface thereof;
 a third substrate having a first electrode disposed on a first surface thereof;
 a first PTC element comprised of a polymer having conductive particles dispersed therein, the first PTC element interposed between the first and second substrates and

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 electrically connecting the first electrode disposed on the first substrate with the first electrode disposed on the second substrate;

5 a second PTC element comprised of a polymer having conductive particles dispersed therein, the second PTC element interposed between the second and third substrates and electrically connecting the second electrode disposed on the second substrate with the first electrode disposed on the third substrate;

10 a first conductive end termination wrapping around a first end of the device; and

a second conductive end termination wrapping around a second end of the device.

15 17. The electrical device of Claim 16 wherein, the first, second and third substrates are electrically insulating.

Sub 14 15 18. The electrical device of Claim 16 wherein, the first, second and substrates are formed from a material selected from the group comprised of ceramic, FR-4 epoxy, glass, and melamine.

16 19. The electrical device of Claim 16 wherein, the first and second PTC elements are electrically connected in parallel.

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~~17~~ 20. The electrical device of Claim ~~16~~

wherein, the first and second end terminations are comprised of a first and a second conductive layer.

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~~18~~ 21. The electrical device of Claim ~~20~~

wherein, the first conductive layer of the first and second end terminations is comprised of copper.

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~~19~~ 22. The electrical device of Claim ~~20~~

wherein, the second conductive layer of the first and second end terminations is comprised of tin.

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~~20~~ 23. The electrical device of Claim ~~16~~ wherein,

the first conductive end termination is in direct contact with first electrode disposed on the third substrate and the first electrode disposed on the second substrate.

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~~21~~ 24. The electrical device of Claim ~~23~~ wherein,

the second conductive end termination is in direct contact with the second electrode disposed on the second substrate and the first electrode disposed on the first substrate.

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~~22~~ 25. The electrical device of Claim ~~24~~ wherein,

when current flows through the device the current flows from the first conductive end termination to the first electrode disposed on the third substrate and the first electrode disposed on the second substrate, through the first and second PTC elements to the second electrode disposed on the second substrate and the first

electrode disposed on the first substrate, to the second conductive end termination.

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26. A surface-mountable electrical circuit protection device comprising:

a first electrically insulating substrate having an electrode disposed on a first surface thereof;

a second electrically insulating substrate having a first electrode disposed on a first surface thereof and a second electrode disposed on a second surface thereof;

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a third electrically insulating substrate having a first electrode disposed on a first surface thereof and a second electrode disposed on a second surface thereof;

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a fourth electrically insulating substrate having a first electrode disposed on a first surface thereof;

a first laminar PTC element comprised of a polymer having conductive particles dispersed therein, the first PTC element interposed between the first and second insulating substrates and electrically connecting the first electrode disposed on the first insulating substrate with the first electrode disposed on the second insulating substrate;

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a second laminar PTC element comprised of a polymer having conductive particles dispersed therein, the second PTC element interposed between the second and third insulating substrates and electrically connecting the second electrode disposed on the second insulating substrate with the first electrode disposed on the third insulating substrate;

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a third laminar PTC element comprised of a polymer having conductive particles dispersed therein, the third PTC element interposed between the third and fourth insulating substrates and electrically connecting the second electrode disposed on the third insulating substrate with the first electrode disposed on the fourth insulating substrate;

a first electrically conductive end termination wrapping around a first end of the device and electrically contacting the first electrode disposed on the fourth insulating substrate, the first electrode disposed on the third insulating substrate, and the first electrode disposed on the second substrate; and

a second electrically conductive end termination wrapping around a second end of the device and electrically contacting the second electrode disposed on the third insulating substrate, the second electrode disposed on the second insulating substrate, and the first electrode disposed on the first insulating substrate.

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24 27. The circuit protection device of Claim ²³26 wherein, the first end termination is disposed on the first and fourth insulating substrates adjacent one end of the device.

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25 28. The circuit protection device of Claim ²³26 wherein, the second end termination is disposed on the first and fourth insulating substrates adjacent a second end of the device.

²³
~~26~~ ²⁹. The circuit protection device of Claim ~~26~~

wherein, the first electrically insulating substrate has a first end and a second end, the first electrode disposed on the first surface of the first electrically insulating substrate extends to the second end but not the first end of the first electrically insulating substrate.

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~~27~~ ³⁰. The circuit protection device of Claim ~~26~~

wherein, the second electrically insulating substrate has a first end and a second end, the first electrode disposed on the first surface of the second electrically insulating substrate extends to the first end but not the second end of the second electrically insulating substrate and the second electrode disposed on the second surface of the second electrically insulating substrate extends to the second end but not the first end of the second electrically insulating substrate.

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~~28~~ ³¹. The circuit protection device of Claim ~~26~~

wherein, the third electrically insulating substrate has a first end and a second end, the first electrode disposed on the first surface of the third electrically insulating substrate extends to the first end but not the second end of the third electrically insulating substrate and the second electrode disposed on the second surface of the third electrically insulating substrate extends to the second end but not the first end of the third electrically insulating substrate.

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29 32. The circuit protection device of Claim 23 wherein, the fourth electrically insulating substrate has a first end and a second end, the first electrode disposed on the first surface of the fourth electrically insulating substrate extends to the first end but not the second end of the fourth electrically insulating substrate.

33. A method for manufacturing an electrical circuit protection device, the method comprising the steps of:
 providing a first and a second substrate;
 forming a first electrode on a first surface of a first substrate;
 forming a first electrode on a first surface of a second substrate;
 providing a first PTC element;
 laminating the first PTC element between the first electrode formed on the first substrate and the first electrode formed on the second substrate to form a laminate;
 forming a first end termination that wraps around a first end of the laminate and is in electrical contact with the first electrode on the first substrate; and
 forming a second end termination that wraps around a second end of the laminate and is in electrical contact with the first electrode on second substrate.

34. The method of Claim 33 wherein, the laminating step is carried out in a heated press.

35. The method of Claim 33 wherein, the first and second substrates are comprised of copper clad FR-4 epoxy and the electrodes are formed by etching away portions of the copper cladding.

36. The method of Claim 33 wherein, the laminate is plated with a conductive layer and the first and second end terminations are formed by removing portions of the conductive layers.

37. A method for manufacturing a plurality of electrical circuit protection devices, the method comprising the steps of:

- providing a first, second and third substrate;
- forming a plurality of first electrodes on a first surface of the first substrate;
- forming a plurality of first electrodes on a first surface of the second substrate;
- forming a plurality of second electrodes on a second surface of the second substrate;
- forming a plurality of first electrodes on a first surface of the third substrate;
- providing a first and a second PTC element;
- laminating the first PTC element between the plurality of first electrodes formed on the first substrate and the plurality of first electrodes formed on the second substrate;
- laminating the second PTC element between the plurality of second electrodes formed on the second substrate and

the plurality of first electrodes formed on the third substrate to form a multi-layered PTC sheet;

forming a plurality of openings in the sheet to expose portions of the multi-layers (i.e., the substrates, the electrodes and the PTC elements);

applying a first conductive layer to the multi-layered PTC sheet and the exposed portions of the multi-layered PTC sheet;

applying a second conductive layer to the first conductive layer;

etching away portions of the first and second conductive layers to create a plurality of first and second end terminations, each of the first end terminations contacting one of the plurality of first electrodes formed on the third substrate and one of the plurality of first electrodes formed on the second substrate, and each of the second end terminations contacting one of the plurality of first electrodes on the first substrate and one of the plurality of second electrodes formed on the second substrate; and

forming the sheet into a plurality of electrical circuit protection devices, each device having one of the plurality of first and second end terminations.

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